

M

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
7 August 2003 (07.08.2003)

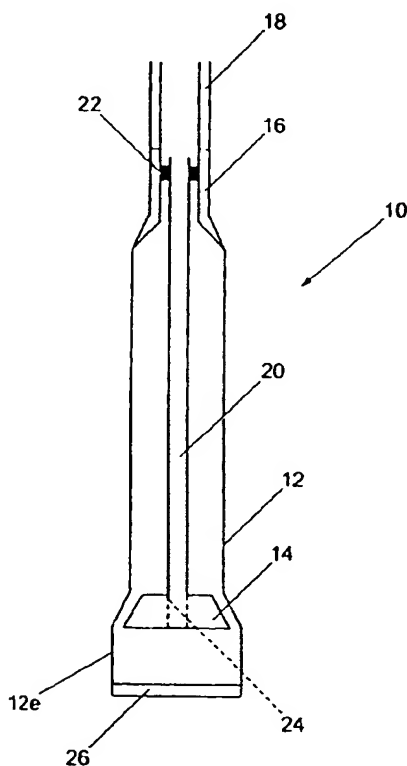
PCT

(10) International Publication Number
WO 03/064813 A1

- (51) International Patent Classification⁷: **E21B 43/10** (74) Agent: **MURGITROYD & COMPANY**; 165-169 Scotland Street, Glasgow G5 8PL (GB).
- (21) International Application Number: **PCT/GB03/00138**
- (22) International Filing Date: 16 January 2003 (16.01.2003) (81) Designated States (national): **AF, AG, AI, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.**
- (25) Filing Language: **English**
- (26) Publication Language: **English**
- (30) Priority Data:
0201955.2 29 January 2002 (29.01.2002) **GB**
- (71) Applicant (for all designated States except US): **e2TECH LIMITED** [GB/NL]; Shell International B.V., PO Box 384, NL-2051 CJ The Hague (NL).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): **BURGE, Philip, Michael** [GB/GB]; Blackchambers, Westhill, Aberdeenshire AB32 7BU (GB).
- (84) Designated States (regional): **ARIPO patent** (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), **Eurasian patent** (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), **European patent** (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), **OAPI patent** (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: **APPARATUS AND METHOD FOR EXPANDING TUBULAR MEMBERS**



(57) Abstract: Apparatus and methods of expanding tubular members are disclosed. In one embodiment, the apparatus includes a vibrating device (16) that is capable of imparting a longitudinal and/or lateral and/or oblique vibration to a tubular member (12) or string (18) as it is being run into a borehole or wellbore. In another embodiment, the vibrating device (16) imparts a longitudinal and/or lateral and/or oblique vibration to a tubular member (12) and/or expander device (14), as the tubular member (12) is being radially expanded by the expander device (14).



WO 03/064813 A1

BEST AVAILABLE COPY



Published:

- with international search report
before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

1 "Apparatus and Method for Expanding Tubular Members"

2

3 The present invention relates to apparatus and
4 methods for expanding tubular members, and in
5 particular apparatus and methods that help to avoid
6 downhole tubulars from becoming differentially stuck
7 when running the tubulars into a borehole and/or when
8 radially expanding them.

9

10 It is known to use downhole tubular members that are
11 capable of being radially expanded to case, line and
12 repair boreholes. The tubular members are typically
13 of a ductile material so that they can undergo
14 plastic and/or elastic deformation to increase their
15 inner and outer diameters.

16

17 Differential sticking is a common occurrence in oil,
18 gas and water wells and is the name given to the
19 jamming of a tubular member in the borehole that is
20 usually caused by a high differential pressure
21 between the borehole and the surrounding formation.
22 The pressure in the borehole can be significantly

1 higher than the pressure in the formation, and the
2 higher pressure in the borehole tends to push
3 downhole tubulars and other apparatus towards the
4 wall of the borehole where they can become jammed or
5 stuck.

6
7 This differential sticking can be made worse by a
8 build up of solids or "filter cake" (filtrate) on the
9 face of the borehole. The build up is typically due
10 to fluid (e.g. mud) loss into the formation because
11 the differential pressure between the borehole and
12 the formation causes the fluid to be forced from the
13 high pressure borehole into the low pressure
14 formation. Solid particles in the mud separate out
15 as the larger particles cannot pass into the
16 formation because of the structure thereof, and the
17 particles tend to form a build up of solids or
18 filtrate on the wall of a borehole. The filtrate is
19 typically a relatively thin coating and can help to
20 seal and stabilise the borehole walls, but too much
21 of this can cause the downhole tubulars and apparatus
22 to stick to the walls, particularly when the tubulars
23 stop moving, and the filtrate acts as a seal.

24
25 According to a first aspect of the present invention,
26 there is provided apparatus for expanding a tubular
27 member, the apparatus comprising a vibrating device
28 and an expander device.

29
30 According to a second aspect of the present
31 invention, there is provided a method of expanding a

1 tubular member in a borehole, the method comprising
2 the step of vibrating the tubular member before,
3 during and/or after expansion.
4

5 The present invention also provides a method of
6 preventing a string from becoming stuck in a
7 wellbore, the method comprising the steps of
8 vibrating the string while being run into the
9 wellbore.
10

11 The string may comprise a string of tubular members,
12 downhole apparatus (e.g. tools, instrumentation,
13 drill bits etc), or a combination of these and other
14 components.
15

16 The vibrating device is typically capable of
17 imparting a longitudinal and/or lateral vibration to
18 the expander device and/or the tubular member. It
19 will be appreciated that a longitudinal vibration
20 means a vibration that is applied on a longitudinal
21 axis of the tubular member and/or the expander
22 device, or on an axis that is coplanar or parallel to
23 the longitudinal axis of the tubular member and/or
24 expander device. A lateral vibration is typically a
25 vibration on an axis that extends across the
26 longitudinal axis of the tubular member (e.g. one
27 that is substantially perpendicular to the
28 longitudinal axis of the tubular member and/or the
29 expander device), or on an axis that is coplanar or
30 parallel to the axis that is substantially
31 perpendicular to the longitudinal axis of the tubular

1 member and/or expander device. It will also be
2 appreciated that the vibrations may be on an oblique
3 axis that is, for example, across the longitudinal
4 axis but not perpendicular thereto. The vibrating
5 device is preferably capable of applying at least
6 longitudinal vibration to the tubular member. The
7 vibrating device may comprise a Baker Oil Tools
8 RATTLER™ downhole tool or the like. The vibrating
9 device provides the advantage that the tubular member
10 and/or the expander device can be vibrated on a
11 longitudinal and/or lateral and/or oblique axis
12 whilst being run into the borehole. Thus, the
13 tubular member is less likely to become stuck due to
14 differential pressure. Also, the vibrating device
15 provides the advantage that the tubular member and/or
16 the expander device can be vibrated on a longitudinal
17 and/or lateral and/or oblique axis whilst the member
18 is being radially expanded. This reduces the amount
19 of friction between the expander device and the
20 tubular member, making the expansion process more
21 efficient and reduces the possibility of the expander
22 device becoming stuck.

23

24 The vibrations are typically applied at least for the
25 duration of the expansion process and/or whilst the
26 tubular member or string is being run into the
27 borehole.

28

29 Optionally, the vibrations may be applied after
30 completion of the expansion process. For example,
31 vibrations may be applied whilst the apparatus is

1 being retrieved from the borehole to reduce friction,
2 or during circulation of cement.

3
4 The vibrating device is typically actuated by the
5 flow of fluid (e.g. mud, water, brine, cement etc)
6 therethrough. Other means of actuation may also be
7 used depending upon the particular type of vibrating
8 device. For example, the vibrating device may be
9 electrically-operated or petrol- or diesel-driven.

10
11 The expander device typically comprises an expansion
12 cone. The cone is preferably of a material that is
13 harder than the tubular member that it has to expand.
14 Steel or a steel alloy is typically used. Tungsten
15 carbide or a ceramic material may also be used.
16 Combinations of these and/or other materials may also
17 be used. For example, a harder material (e.g.
18 ceramic, tungsten carbide etc) may be used to coat
19 the portion(s) of the cone that come into contact
20 with the tubular member during expansion thereof.

21
22 The expander device is typically attached to a
23 conduit, such as a portion of drill string, a coiled
24 tubing string or the like. It is preferable that the
25 expander device be coupled to a conduit having a
26 relatively small diameter. The vibrating device is
27 preferably coupled (e.g. by screw threads) to the
28 tubular member that is to be expanded. The tubular
29 member is typically coupled to a string (e.g. a
30 string of drill pipe or a coiled tubing string). In
31 this particular embodiment, a seal assembly is

1 preferably located between the conduit and the
2 tubular member. The seal assembly preferably allows
3 the conduit with the expander device to move, whilst
4 the tubular member and string remain stationary.
5 This has the advantage that the expansion of the
6 tubular member does not require movement of the
7 string.

8
9 Alternatively, the vibrating device may be coupled
10 into the same conduit as the expander device. The
11 tubular member is typically coupled to a string (e.g.
12 a string of drill pipe or a coiled tubing string).
13 In this particular embodiment, a seal assembly is
14 preferably located between the conduit and the
15 string. The seal assembly preferably allows the
16 conduit with the expander device to move, whilst the
17 tubular member and string remains stationary. This
18 has the advantage that the expansion of the tubular
19 member does not require movement of the string.

20
21 The expander device is preferably provided with a
22 through-bore or aperture that allows fluid to pass
23 through the conduit to which it is attached, and also
24 through the expander device.

25
26 An end of the tubular member is preferably closed.
27 The end can be closed using a threaded cap, ball
28 catcher or the like. Thus, fluid pressure is
29 retained within the tubular member. The end of the
30 tubular member is optionally pre-expanded so that the
31 expander device (e.g. a cone) can be located therein.

1 The expander device can be provided with a seal (e.g.
2 an O-ring or lip-type seal) so that fluid pressure is
3 retained on one side of the device (e.g. underneath).

4
5 The step of actuating the vibrating device typically
6 comprises circulating fluid therethrough, although
7 the particular method used depends upon the type of
8 vibrating device that is used. The fluid may be
9 circulated using any conventional means.

10
11 The step of actuating movement of the expander device
12 typically comprises the step of circulating fluid
13 through the conduit and the expander device. This
14 builds up fluid pressure (typically under the
15 expander device), causing it to be forced upwards and
16 thus expand the tubular member.

17
18 The method typically includes the additional step of
19 coupling the vibrating device into a first string.
20 The vibrating device may be coupled into the string
21 using any conventional means (e.g. welding, screw
22 threads etc). The expander device is typically
23 coupled to a second string. In certain embodiments,
24 the first string and the second string are the same.
25 In certain other embodiments, the first string
26 comprises a string of drill pipe, a coiled tubing
27 string or the like, and the second string comprises a
28 conduit of relatively small outer diameter, e.g.
29 drill pipe or coiled tubing. The method may also
30 include the additional step of coupling the tubular
31 member into the first string. The tubular member may

1 be coupled to the first string using any conventional
2 means (e.g. screw threads, welding etc).

3
4 Optionally, the method may include the additional
5 step of circulating cement into an annulus between
6 the tubular member and the second conduit. In this
7 particular embodiment, the vibrating device can be
8 used to keep the cement in the annulus moving and
9 prevents solids within the cement from settling, both
10 of which help to improve the final bond.

11
12 Embodiments of the present invention shall now be
13 described, by way of example only, and with reference
14 to the accompanying drawings in which:

15 Fig. 1 is a schematic representation of an
16 embodiment of apparatus for expanding a tubular
17 member; and

18 Fig. 2 is a schematic representation of an
19 alternative embodiment of apparatus for
20 expanding a tubular member.

21
22 Referring to the drawings, Fig. 1 shows a first
23 embodiment of apparatus, generally designated 10, for
24 use when expanding a downhole tubular 12. The
25 downhole tubular 12 may comprise any tubular, such as
26 drill pipe, liner, casing or the like and is
27 typically of a ductile material so that it can be
28 radially expanded, as will be described. The radial
29 expansion of the tubular member 12 typically causes
30 the member 12 to undergo plastic and/or elastic

1 deformation to increase its inner and outer
2 diameters.

3
4 Plastic deformation is a result of the cone 14 being
5 pushed through the tubular member 12, which forces
6 the material (e.g. steel) of the member 12 to bend
7 and stretch around the cone 14 so that it assumes a
8 larger inner and outer diameter. This is because the
9 wall of the tubular 12 engages the face of the cone
10 14 and is deflected outwardly, as shown schematically
11 in Figs 1 and 2. The material of the tubular 12 is
12 typically ductile so that it can deform around the
13 cone 14, providing that the cone 14 is pushed or
14 pulled through the tubular 12 with sufficient force
15 to stretch or bend the material of the tubular 12.
16 The stretched configuration of the material of the
17 tubular member 12 is typically substantially retained
18 after the radial expansion force exerted by the cone
19 14 is removed; the tubular member 12 relaxes slightly
20 after is it deformed or stretched and this relaxation
21 is termed elastic deformation. The recovery by
22 elastic deformation is typically significantly less
23 than the expansion by plastic deformation, and
24 results in the inner and outer diameters of the
25 expanded tubular member 12 reducing slightly from the
26 initially radially expanded state.

27
28 The apparatus 10 includes an expansion cone 14 that
29 can be of any conventional design. The expansion
30 cone 14 is typically of a material that is harder
31 than the material of the tubular 12 that it has to

1 expand. Steel or steel alloys can be used for the
2 cone 12, although ceramic or tungsten carbide may
3 also be used. It will also be appreciated that
4 combinations of these and other materials can be
5 used. For example, the harder materials (e.g.
6 ceramic, tungsten carbide) can be used only on the
7 faces of the cone 14 that come into contact with the
8 tubular member 12 during expansion.

9
10 The maximum outer diameter of the expander cone 14 is
11 typically the same as or slightly less than the final
12 inner diameter of the member 12 after it has been
13 expanded.

14
15 The cone 14 is typically located in a pre-expanded
16 portion 12e of the tubular 12. However, if a
17 collapsible cone (not shown) is used then this may
18 not be necessary. The tubular 12 is typically
19 located in a second conduit (not shown) in use, where
20 the second conduit may comprise an open borehole or a
21 pre-installed casing, liner or the like. The outer
22 diameter of the pre-expanded portion 12e is typically
23 less than the inner diameter of the second conduit so
24 that the apparatus 10 can be run into the second
25 conduit in a conventional manner.

26
27 The expansion cone 14 can optionally include an
28 inflatable element (e.g. a packer), the function of
29 which shall be described below.

30

1 In the embodiment shown in Fig. 1, a vibrating device
2 16 is attached using any conventional means (e.g.
3 screw threads) to the tubular 12. The vibrating
4 device 16 is used to impart an axial (longitudinal)
5 and/or lateral vibration to the tubular 12 and/or
6 cone 14. Drill pipe 18 or drill collars are
7 typically attached above the vibrating device 16, the
8 drill pipe 18 typically extending back to the
9 surface. The drill pipe 18 typically forms a string
10 of tubular drill members or the like. Coiled tubing
11 may be used in place of the drill pipe 18. The
12 string of drill pipe 18 or coiled tubing provides a
13 conduit back to the surface or vessel for circulation
14 of fluids, and also to facilitate manipulation of the
15 tubulars and the cone 14.

16
17 The longitudinal vibration is applied on a plane that
18 is co-planar with or parallel to a longitudinal axis
19 of the tubular member 12 and/or the expander device
20 14. Similarly, the lateral vibration is applied on a
21 plane that is co-planar with or parallel to an axis
22 that is perpendicular to the longitudinal axis of the
23 tubular member and/or the expander device. Indeed,
24 the vibrations may be on an axis or plane that is
25 oblique, for example an axis that is set at an angle
26 between the longitudinal and lateral axes.

27
28 The vibrating device 16 can be of any conventional
29 design, and could be, for example, a Baker Oil Tools
30 RATTLER™ (product family no H14065). The RATTLER™ is
31 a downhole vibration tool that is designed primarily

1 for use in fishing operations and imparts a low
2 frequency impact directly into a fish. The tool
3 operates by circulating fluid therethrough and
4 varying the amount of fluid varies the impact rate
5 directly. A circulation sub (not shown) can be used
6 below the tool to allow unrestricted fluid flow
7 therethrough, and a safety joint may also be used
8 below the tool if required.

9
10 The tool typically imparts only a longitudinal or
11 axial vibration, but it will be appreciated that
12 other tools that impart longitudinal, lateral and/or
13 oblique vibrations simultaneously or sequentially may
14 be used.

15
16 The frequency of vibration typically depends upon the
17 size and type of tubular, and also the type of
18 formation as the particular filtrate can affect the
19 tendency of the tubular member to stick to the wall
20 of the borehole. Thus, it may be necessary to adjust
21 the frequency and/or amplitude of the vibrations
22 accordingly.

23
24 The amplitude of the vibrations can be chosen to suit
25 the particular size and type of tubular, and also the
26 particular filtrate that is present on the walls of
27 the borehole.

28
29 It will be appreciated that the frequency and/or
30 amplitude of the vibrations provided by the vibrating
31 device 16 can be increased and decreased during use

1 of the device 16. For example, where the RATTLER™ is
2 being used, the amount of fluid that is circulated
3 through the tool can be changed to vary the frequency
4 of the vibration directly. That is, increasing the
5 amount of fluid flow typically increases the
6 frequency of vibration, and conversely, reducing the
7 amount of fluid flow typically reduces the frequency.
8 Also, the amount of fluid passing through the
9 RATTLER™ can affect the amplitude of the vibrations
10 accordingly. That is, the more fluid that is passed
11 through the tool, the higher the amplitude of the
12 vibrations that it imparts.

13
14 The expansion cone 14 is attached (e.g. by screw
15 threads, welding or the like) to a length of conduit
16 20. Conduit 20 is typically a thin pipe (e.g. with a
17 small wall thickness and/or outer diameter) and is
18 used as a fluid conduit between the drill pipe 18 and
19 the expansion cone 14. The conduit 20 is located
20 within the drill pipe 18 through a seal assembly 22
21 that provides for upward movement of the cone 16
22 during the expansion process whilst sealing off the
23 interior of the tubular 12. Note that "upward" is
24 being used with reference to the orientation of the
25 apparatus 10 in Fig. 1.

26
27 The cone 14 is provided with a through-bore 24 and a
28 one-way or check valve (not shown). The check valve
29 can be incorporated as part of the conduit 20 or the
30 drill pipe 18. This allows fluid pumped from the
31 surface to flow down through the drill pipe 18,

1 through the conduit 20 and out through the cone 14
2 into the tubular 12, but the check valve will not
3 allow fluid to flow in the opposite direction. Note
4 that tubular 12 is provided with a threaded cap 26 or
5 other barrier (e.g. a ball catcher) that restrains
6 fluid flow out of the tubular 12. It will also be
7 noted that fluid flows through the vibrating device
8 16, thus causing it to operate. It will be
9 appreciated that some forms of vibrating device 16
10 may not be actuated by fluid flow through them.

11
12 Expansion is initiated by pumping fluid down the
13 drill pipe 18 and the conduit 20. Hydraulic pressure
14 is contained below the cone 14 at the cap 26 and this
15 results in a build-up of pressure causing upward
16 movement of the cone 14. The cone 14 can be provided
17 with a seal (e.g. an O-ring or lip-type seal) that
18 engages an inner face of the tubular 12 to retain
19 fluid pressure below the cone 14. However, contact
20 between an expansion face of the cone 14 and an inner
21 face of the tubular 12 can provide a metal-to-metal
22 seal.

23
24 Movement of the cone 14 causes it to engage the
25 tubular 12 and thus radially expand the tubular 12 by
26 plastically and/or elastically deforming it. The
27 expansion of the tubular 12 can be used to cause it
28 to engage the second conduit in which it is located,
29 although this is not essential as a spacer, seal,
30 packer or the like can be used therebetween. Also,

1 cement can be used in the annulus between the tubular
2 12 and the second conduit, as will be described.

3
4 The inflatable element that can be included as part
5 of the cone 14 can be used to further inflate the
6 pre-expanded portion 12e into contact with the second
7 conduit. Also, the inflatable element can be used as
8 a temporary anchor that secures the tubular 12 and
9 holds it in position whilst it is being radially
10 expanded. The inflatable element can either be
11 deflated so that it moves with the cone 14, or can be
12 released therefrom so that the cone 14 travels on its
13 own, the inflatable element being recovered
14 thereafter. A conventional latching mechanism can be
15 used to couple the inflatable element to the cone 14,
16 if required.

17
18 The fluid flow also activates the vibrating device 16
19 and the vibration therefrom keeps the tubular 12
20 moving and substantially prevents it from becoming
21 differentially stuck. It will be appreciated that
22 the tubular 12 may become differentially stuck if it
23 is not centralised within the second conduit
24 (typically a borehole).

25
26 Note that the tubular 12 can be vibrated whilst it is
27 being run into the second conduit by circulating
28 fluid as described above. It will be appreciated
29 that a ball catcher (not shown) may be used in place
30 of the threaded cap 26 to allow fluid to be
31 circulated whilst the apparatus 10 is being run in.

1 This is particularly advantageous where the tubular
2 12 is being located in a long, deviated or horizontal
3 borehole where it is likely that the tubular 12 will
4 become differentially stuck.

5
6 It will also be appreciated that cement can be
7 circulated (using any conventional means) in the
8 annulus between the tubular 12 and the second conduit
9 to keep the tubular 12 in place. The threaded cap 26
10 can be drilled out to allow for the circulation of
11 cement in the conventional manner. The vibrations
12 from the vibrating device 16 will help to keep the
13 cement moving between the second conduit and the
14 tubular 12, and can also help prevent solids in the
15 cement from settling, thus improving the final bond
16 between the tubular 12 and the second conduit.

17
18 A further advantage of the apparatus 10 is that the
19 expansion process does not require any movement of
20 the drill pipe 18. Movement of the expansion cone 14
21 is decoupled from movement of the drill pipe 18 and
22 thus the tubular 12. Additionally, in the event that
23 the expansion cone 14 becomes stuck, the drill pipe
24 18 and vibrating device 16 can be removed from the
25 second conduit and remedial action can be taken to
26 retrieve the conduit 20 and expansion cone 14.

27
28 It will be appreciated that once the tubular 12 has
29 been radially expanded, the drill pipe 18 can be
30 rotated against the tubular 12 to release the pipe 18
31 from the tubular 12 so that the tubular 12 remains in

1 *situ*. The remainder of the apparatus can then be
2 withdrawn from the borehole.

3
4 Alternatively, the tubular 12 can be provided with a
5 screw-threaded attachment at an end thereof so that
6 when the tubular 12 is radially expanded, the screw-
7 threads are released from the threads on the
8 vibrating device 16, allowing the apparatus to be
9 retrieved whilst the tubular 12 remains *in situ*.

10

11 Referring now to Fig. 2, there is shown an
12 alternative apparatus 100 for expanding a tubular
13 112. Apparatus 100 is similar to apparatus 10 and
14 like parts shall be designated with the same
15 reference numeral pre-fixed "1".

16

17 The main difference between apparatus 100 and
18 apparatus 10 is that the vibrating device 116 is
19 located in the conduit 120 and the tubular 112 is
20 coupled directly to the drill pipe 118. The
21 vibrating device 116 can be used to impart lateral
22 and/or radial vibrations to the cone 114, which can
23 be transferred to the tubular 112 either by contact
24 between the cone 114 and the tubular 112, or through
25 the seal assembly 122. This embodiment thus has the
26 same advantages and benefits as the previous
27 embodiment.

28

29 In addition to those, the vibrating device 116 can be
30 used to impart longitudinal and/or lateral vibrations
31 to the cone 114. The vibrations reduce the friction

1 between the cone 114 and the tubular 112, thus making
2 the expansion process more efficient.

3

4 Modifications and improvements may be made to the
5 foregoing without departing from the scope of the
6 present invention.

1 CLAIMS

2

3 1. Apparatus for expanding a tubular member, the
4 apparatus comprising a vibrating device (16, 116)
5 and an expander device (14, 114).

6

7 2. Apparatus according to claim 1, wherein the
8 vibrating device (16, 116) is capable of imparting a
9 longitudinal and/or lateral and/or oblique vibration
10 to the expander device (14, 114) and/or the tubular
11 member (12, 112).

12

13 3. Apparatus according to either preceding claim,
14 wherein the vibrating device (16, 116) is actuated
15 by a flow of fluid therethrough.

16

17 4. Apparatus according to claim 1 or claim 2,
18 wherein the vibrating device (16, 116) is
19 electrically-operated or petrol- or diesel-driven.

20

21 5. Apparatus according to any preceding claim,
22 wherein the expander device (14, 114) comprises an
23 expansion cone.

24

25 6. Apparatus according to any preceding claim,
26 wherein the expander device (14, 114) is attached to
27 a conduit (20, 120).

28

29 7. Apparatus according to claim 6, wherein the
30 conduit (20, 120) has a relatively small diameter.

31

- 1 8. Apparatus according to claim 6 or claim 7,
2 wherein the vibrating device (16, 116) is coupled to
3 the tubular member (12, 112) that is to be expanded.
4
- 5 9. Apparatus according to claim 8, wherein the
6 tubular member (12) and the vibrating device (16)
7 are coupled into a string (18).
8
- 9 10. Apparatus according to claim 9, wherein a seal
10 assembly (22) is located between the conduit (20)
11 and the tubular member (12).
12
- 13 11. Apparatus according to claim 10, wherein the
14 seal assembly (22) allows the conduit (20) with the
15 expander device (14) to move, whilst the tubular
16 member (12) and string (18) remain stationary.
17
- 18 12. Apparatus according to claim 6, wherein the
19 vibrating device (116) is coupled into the same
20 conduit (120) as the expander device (114).
21
- 22 13. Apparatus according to claim 12, wherein the
23 tubular member (112) is coupled into a string (118).
24
- 25 14. Apparatus according to claim 13, wherein a seal
26 assembly (122) is located between the conduit (120)
27 and the string (118).
28
- 29 15. Apparatus according to claim 14, wherein the
30 seal assembly (122) allows the conduit (120) with
31 the expander device (114) to move, whilst the
-

1 tubular member (112) and string (118) remain
2 stationary.
3

4 16. Apparatus according to any preceding claim,
5 wherein the expander device (14, 114) is provided
6 with a through-bore (24, 124) or aperture that
7 allows fluid to pass through the conduit (20, 120)
8 to which it is attached, and also through the
9 expander device (14, 114).
10

11 17. Apparatus according to any preceding claim,
12 wherein an end of the tubular member (12, 122) is
13 closed.
14

15 18. A method of expanding a tubular member in a
16 borehole, the method comprising the step of
17 vibrating the tubular member (12, 112) before,
18 during and/or after expansion.
19

20 19. A method according to claim 18, wherein the
21 step of vibrating the tubular member (12, 112)
22 includes the additional step of actuating a
23 vibrating device (16, 116) attached to the tubular
24 member (12, 112).
25

26 20. A method according to claim 19, wherein the
27 step of actuating the vibrating device (16, 116)
28 comprises circulating fluid therethrough.
29

30 21. A method according to any one of claims 18 to
31 20, wherein the method includes the step of
32 actuating movement of an expander device (14, 114)

1 to impart a radial expansion force to the tubular
2 member (12, 112).

3

4 22. A method according to any one of claims 18 to
5 21, wherein the method includes the additional step
6 of coupling the vibrating device (16, 116) into a
7 first string (18).

8

9 23. A method according to claim 22, wherein the
10 method includes the additional step of coupling the
11 expander device (14, 114) into a second string (20,
12 120).

13

14 24. A method according to any one of claims 18 to
15 23, wherein the tubular member (12, 112) is vibrated
16 on a longitudinal and/or lateral and/or oblique
17 axis.

18

19 25. A method of expanding a tubular member in a
20 borehole, the method comprising the step of
21 vibrating an expander device (14, 114) during
22 expansion of the tubular member (12, 112).

23

24 26. A method according to claim 25, wherein the
25 step of vibrating the expander device (14, 114)
26 includes the additional step of actuating a
27 vibrating device (16, 116) attached to the expander
28 device (14, 114).

29

30 27. A method according to claim 26, wherein the
31 step of actuating the vibrating device (16, 116)
32 comprises circulating fluid therethrough.

1

2 28. A method according to any one of claims 25 to
3 27, wherein the method includes the step of
4 actuating movement of an expander device (14, 114)
5 to impart a radial expansion force to the tubular
6 member (12, 112).

7

8 29. A method according to any one of claims 18 to
9 23, wherein the expander device (14, 114) is
10 vibrated on a longitudinal and/or lateral and/or
11 oblique axis.

12

13 30. A method of preventing a string from becoming
14 stuck in a wellbore, the method comprising the steps
15 of vibrating the string (18) while being run into
16 the wellbore.

17

18 31. A method according to claim 30, wherein the
19 step of vibrating the string (18) comprises the step
20 of actuating a vibrating device (16).

21

22 32. A method according to claim 31, wherein the
23 step of actuating the vibrating device (16)
24 comprises circulating fluid therethrough.

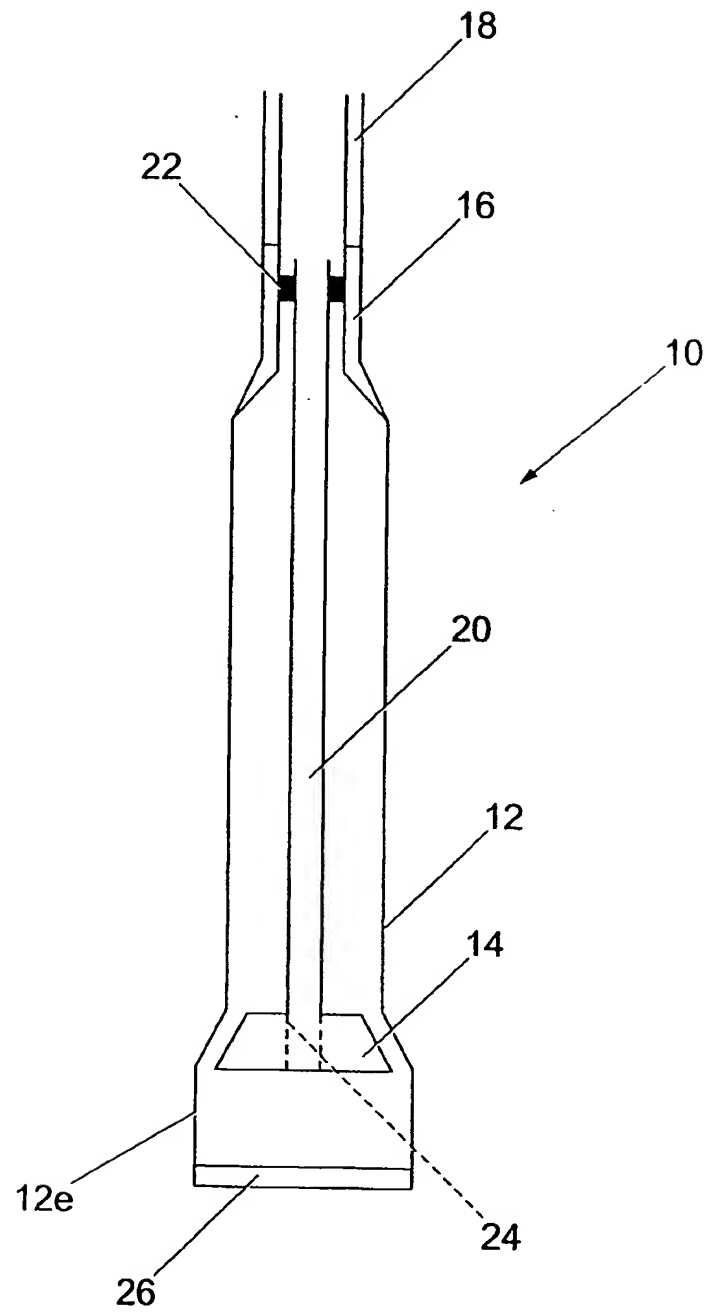
25

26 33. A method according to any one of claims 30 to
27 32, wherein the method includes the additional step
28 of coupling the vibrating device (16) into the
29 string (18).

30

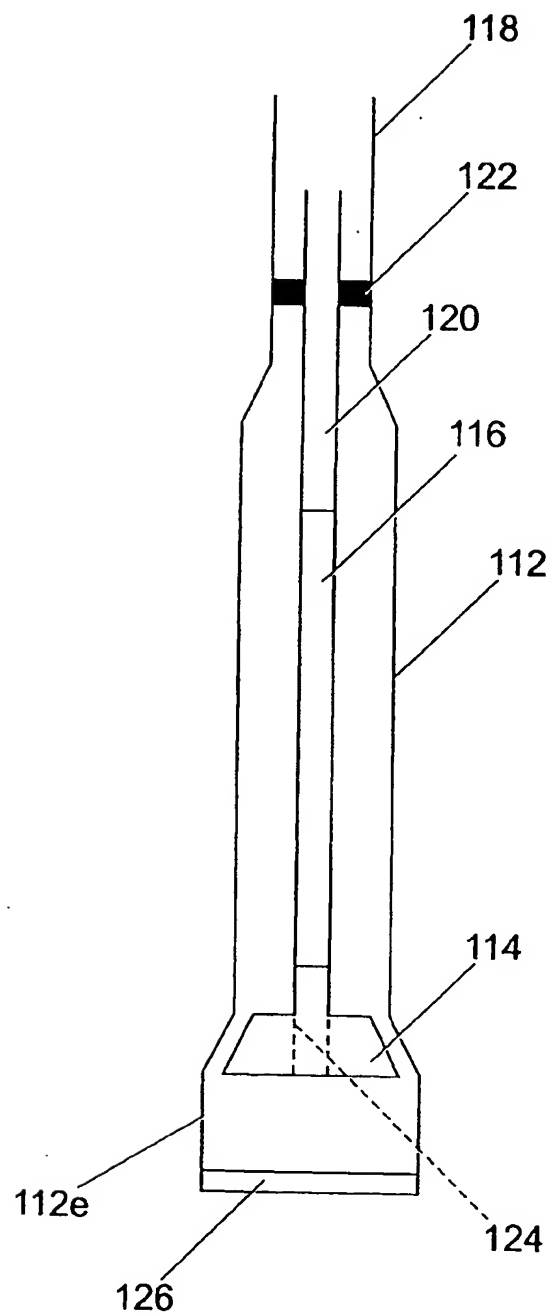
- 1 34. A method according to any one of claims 30 to
 - 2 33, wherein the string (18) is vibrated on a
 - 3 longitudinal and/or lateral and/or oblique axis.
-

1 / 2

*Fig. 1*

SUBSTITUTE SHEET (RULE 26)

2 / 2

*Fig. 2*

SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

Intern al Application No

PCT/GB 03/00138

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B43/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 98 00626 A (SHELL CANADA LTD ;SHELL INT RESEARCH (NL)) 8 January 1998 (1998-01-08) page 7, line 9-12 figure 1	1, 18, 25, 30
X	US 4 058 163 A (YANDELL JAMES L) 15 November 1977 (1977-11-15) abstract	30-34
X	US 4 384 625 A (ROPER WILBUR F ET AL) 24 May 1983 (1983-05-24) column 6, line 50-54 figure 1	30-34
X	GB 2 261 238 A (BP EXPLORATION OPERATING) 12 May 1993 (1993-05-12) page 4, line 31 -page 5, line 5	30-34
	-/--	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

*** Special categories of cited documents :**

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *&* document member of the same patent family

Date of the actual completion of the international search

21 May 2003

Date of mailing of the international search report

27/05/2003

Name and mailing address of the ISA

European Patent Office, P.O. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax (+31-70) 340-3016

Authorized officer

Schouten, A

INTERNATIONAL SEARCH REPORT

Intern al Application No

PCT/GB 03/00138

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 272 924 A (BP CHEM INT LTD ;BP EXPLORATION OPERATING (GB)) 1 June 1994 (1994-06-01) page 3, line 5-14 claim 1	30-34
X	US 4 890 682 A (WORRALL ROBERT N ET AL) 2 January 1990 (1990-01-02) abstract claim 19 figure 1	30-34

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 03/00138

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this International application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/GB 03 00138

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-29

Method and apparatus for expanding a tubular member comprising a vibrating device and an expander.

2. Claims: 30-34

A method of preventing a string from becoming stuck in a wellbore by vibrating the string while running in.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 03/00138

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9800626	A	08-01-1998	AU 723337 B2	24-08-2000
			AU 3442097 A	21-01-1998
			BR 9710016 A	10-08-1999
			CA 2260191 A1	08-01-1998
			EA 543 B1	28-10-1999
			WO 9800626 A1	08-01-1998
			EP 0907822 A1	14-04-1999
			JP 2001508144 T	19-06-2001
			NO 986171 A	22-02-1999
			NZ 333945 A	27-03-2000
US 4058163	A	15-11-1977	NONE	
US 4384625	A	24-05-1983	CA 1167832 A1	22-05-1984
			GB 2088438 A , B	09-06-1982
			NO 814043 A	01-06-1982
GB 2261238	A	12-05-1993	NONE	
GB 2272924	A	01-06-1994	NONE	
US 4890682	A	02-01-1990	CA 1319675 A1	29-06-1993
			DE 3776959 D1	09-04-1992
			EP 0245892 A2	19-11-1987

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☒ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☒ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☒ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.